Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

U. S. DEPT. OF [illegible]
[illegible]
OCT 13 1964

99.9
764 Un
Cop. 2

Research Note

C & R-[illegible]

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
OGDEN UTAH

U.S. Forest Service
Research Note INT-21 1964

FIELD CORRELATION OF TWO NEUTRON-SCATTERING SOIL MOISTURE METERS

John D. Schultz[1]

ABSTRACT

Operation of two neutron soil moisture probes of different design was compared under identical conditions. Reports development of a method for depth referencing one probe with respect to the other for obtaining moisture measurements at comparable depths. Correlation curves for data obtained with both probes indicate the best relative positioning of these two probes when one is employed in lieu of the other.

INTRODUCTION

Measuring soil moisture by the neutron-scattering method has become increasingly common in recent years. As this method gains wider acceptance and usage among scientists, many of the attendant problems will be investigated more thoroughly. One such problem is the substitution of one moisture-measuring instrument for another when a malfunction develops in the instrument used initially in an investigation. The problem is not restricted only to situations of malfunctioning; it may also arise when the original instrument is unavailable for use at a time when measurements must be made to detect changes in soil moisture over short periods of time.

Recent publications have emphasized field calibration of instruments used in the neutron-scattering method (Sartz and Curtis 1961; Van Bavel, Nixon, and Hauser 1963), but such calibrations refer principally to individual instruments for the particular soils in which they are used. What calibration is necessary when two different instruments are used to measure soil moisture in the zone surrounding the same access tube? This paper suggests a solution to the problem of translating data obtained by a substitute instrument into a set of data comparable to what might have been obtained with the original instrument.

---

[1] Formerly research forester, Intermountain Forest and Range Experiment Station, Forestry Sciences Laboratory, Logan, Utah, maintained in cooperation with Utah State University; now on staff of Utah State University.

PROBE CORRELATION

A calibration curve is provided by the manufacturer for each neutron soil moisture meter. Laboratory calibrations are presented as curves which show the count rate as a percentage of the reference standard (relative count) versus moisture content (volume percent moisture) of the medium or as moisture percent of the soil versus count rate in counts per minute. Some authors (Merriam 1959; Van Bavel 1958) have reported that manufacturers' laboratory calibration curves may be valid for many soils, but Sartz and Curtis (1961) stated that one curve may not apply for all soils. In this investigation, it was assumed, for the sake of simplicity, that curves supplied by the manufacturer are adequate.

Actually, substituting one moisture meter for another should simply be a matter of taking readings with the substitute instrument and converting them to moisture values that the other meter might have yielded. This procedure uses the calibration curves referred to above, but the relation between the two meters is a correlation rather than a calibration in the usual sense. The correlation curve developed is between the soil moisture readings obtained with both probes.

Van Bavel, Nixon, and Hauser (1963, p. 24) pointed out that a direct comparison between field readings obtained with a calibrated and an uncalibrated meter can yield a calibration curve for the latter. This requires, however, that both meters be of the same manufacture and have identical design.

Soil moisture depth probes have a radioactive source attached either to the side of the detector tube at its approximate midlength or to the end of the tube. Both types are in wide use. Our problem hinges on the correlation that may exist between two such differently designed probes that are individually calibrated already.

PROBES AND ACCESS TUBES USED

A Nuclear-Chicago[2] Model P-19 soil moisture depth probe with a Model 2800 scaler has been used regularly for 2 years to measure soil moisture changes on the same fairly uniform site. This probe is 1.50 inches in diameter, and its radioactive source is near the midlength of the detector tube. It is used in seamless steel access tubing. The instrument was calibrated by the manufacturer specifically for the type of tube used, which is 1.555 inches inside diameter and 1.625 inches outside diameter.

Early in 1963, a Troxler Model 105 moisture probe and Model 200B scaler were purchased. The manufacturer calibrated this probe for the same access tubing. The Model 105 probe is 1.50 inches in diameter and the radioactive source is located at the end of the detector tube. Thus, for purposes of comparing the two probes, site and tube conditions under which comparable readings were obtained were the same.

---

[2] No endorsement or preferential treatment by the U.S. Department of Agriculture is intended by reference to trade names and company names.

DEPTH REFERENCING OF PROBES

Each measurement of soil moisture by the neutron-scattering method is made at a specific distance below the soil surface. This implies a reference point in the probe to which the depth measurement is made. Its position can be determined in several different ways: (1) by passing a survey meter (Geiger tube) up and down the probe until the highest reading is obtained, (2) by taking 1-minute counts by 1-inch increments as the probe is lowered through an access tube positioned in a container holding a 2- to 4-inch layer of water, (3) by following the field method of curve adjustment described by Stewart and Taylor (1957), or (4) by accepting the manufacturers' statements concerning the location of the effective center of measurement.

In the P-19 probe, this reference point is considered to be where the radioactive source is located. For the Troxler Model 105 probe, all methods except the first listed above can be used. Because the radioactive source is encapsulated immediately below the detector tube, a survey meter would easily locate the source position but it would not detect the effective center of measurement. This point in the Troxler probe is less definable than in the P-19 probe because the neutron cloud may be altered by the presence of a moist or dry stratum that lies between the plane of the source and the assumed effective center. When this occurs, readings may be inconsistent with the average moisture content for that depth. This situation is alluded to by several authors (Van Bavel, Nixon, and Hauser 1963; Lawless, MacGillivray, and Nixon 1963).

Because the P-19 probe was the instrument used initially to obtain data for the soil moisture depletion study under consideration, it is desirable to determine what placement of the substitute probe (in this instance, the Troxler Model 105) yields the highest correlation with soil moisture data obtained with the P-19 probe. Thus, although the manufacturer of the Model 105 probe may state that the effective center is located 4 inches above the bottom of the detector tube, field experience might indicate that a higher correlation with another probe would result from a different point of reference.

Lawless, MacGillivray, and Nixon (1963, p. 506) recognize that the effective center of the Troxler Model 104 probe (1.865 inches diameter) varies with soil moisture content and is not actually a fixed point. So little information is available for the Troxler Model 105 probe that it is probably reasonable to apply the same conclusion to this 1.50-inch diameter probe. As Merriam and Copeland (1963) pointed out, "It is apparent that all the problems involved in obtaining the 'best' neutron probe design are not yet solved."

ACQUISITION AND EVALUATION OF DATA

Access tubing was installed on the study site to depths ranging from 6 to 10 feet in the summer of 1961. During the 1963 field season, comparative readings were taken with both probes on four dates. The radioactive source in the Model P-19 probe was used as the reference point to which depth readings were taken. For a given moisture reading, the Model 105 probe was referenced so that the source was at one of four positions with respect to the source of the P-19 probe. These positions were: (1) at the same depth, (2) 3 inches lower than the P-19 source, (3) 4 inches lower, and (4) 5 inches lower. In the second, third, and fourth positions, the so-called effective center of the Troxler probe was near the same position as that of the Nuclear-Chicago probe. Only one of these four positions was used on any given date of measurement.

The data presented herein were obtained from 10 access holes and from nine vertical positions in those holes. Depth below soil surface in inches and numbers of observations for each vertical position, in that order, were as follow: 18-10, 30-10, 42-10, 54-10, 66-10, 78-9, 90-7, 102-7, 114-7.

Readings obtained with each probe on the same day were first converted to percent soil moisture (by volume) using the calibration curve provided for each instrument. Data were then paired according to position depth in each access hole and assembled as shown in table 1.

Table 1.--Paired soil moisture readings, Troxler Model 105 probe and Nuclear-Chicago Model P-19 probe[1]

Depth (inches)	Volume percent soil moisture					
	Hole 1		Hole 2		Hole 3	
	105	P-19	105	P-19	105	P-19
18	37.7	31.5	35.8	30.7	25.0	20.5
30	40.0	29.8	34.4	29.8	27.8	22.4
42	41.4	35.6	37.8	27.4	24.3	19.4
54	44.2	38.4	43.9	37.2	16.4	13.6
66	39.3	34.9	41.0	35.3	24.2	22.0
78	29.7	26.1	27.6	24.6	21.4	15.7
90	36.2	30.3	38.8	33.1	30.4	25.4
102	42.0	37.5	44.7	39.8	33.8	30.1
114	43.4	36.1	43.1	38.9	36.8	32.8

[1] Taken at Davis County Experimental Watershed, Utah, on August 7, 1963.

The assembled data were plotted in figure 1. Because the form of the data so nearly represented straight lines, simple linear correlations were run. The correlation coefficients show that exceptionally high linear correlation exists between the data obtained with the two probes for any of the four relative radioactive source positions. At each relative position for 80 observations, all four coefficients are very highly significant.

Visual consideration of the four graphs indicates that the 4-inch displacement of sources (curve C) would yield the most satisfactory set of substitute data if the Troxler probe were used in lieu of the Nuclear-Chicago instrument. The scatter of data is least for the 4-inch source difference; it is greatest for the placement where both sources are at the same depth (curve A), although the variation of data is not great in any of the four situations.

Plotting of the R^2 or variances of the data reinforces the conclusion drawn above. Figure 2 shows that the highest accounting of variance is obtained when the Model 105 probe is positioned within an access tube so that its radioactive source is 4 inches lower than the P-19 source for a comparable measurement at a specific depth. If the Troxler probe source were positioned 1 inch higher or 6 inches lower than the Nuclear-Chicago probe source, it is reasonable to expect that even greater variation in data would be obtained.

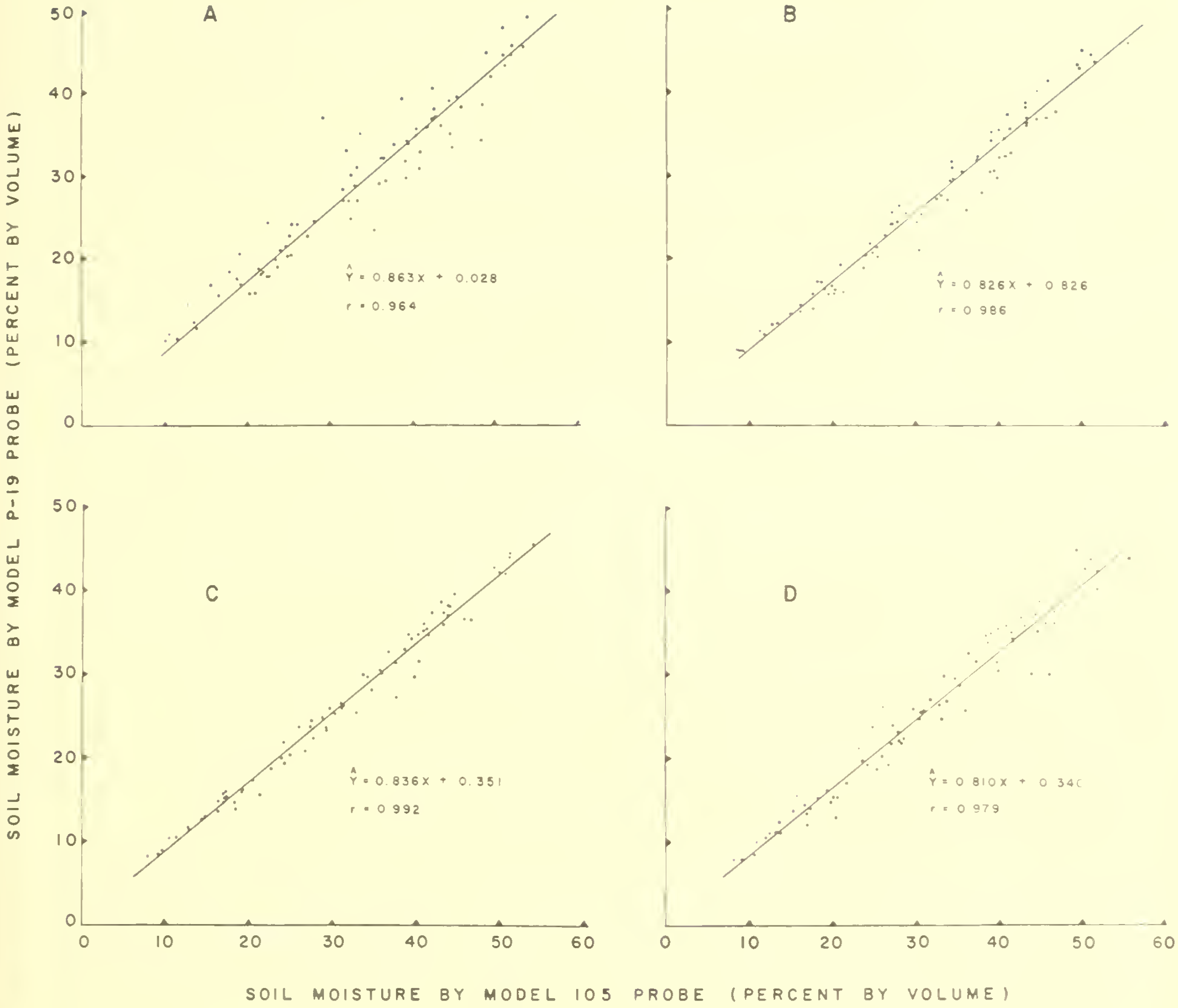

Figure 1.--Relation between soil moisture readings obtained with Nuclear-Chicago Model P-19 moisture probe and Troxler Model 105 moisture probe: A, Radioactive sources at same depth; B, Model 105 source 3 inches lower than source in P-19 probe; C, Model 105 source 4 inches lower; D, Model 105 source 5 inches lower.

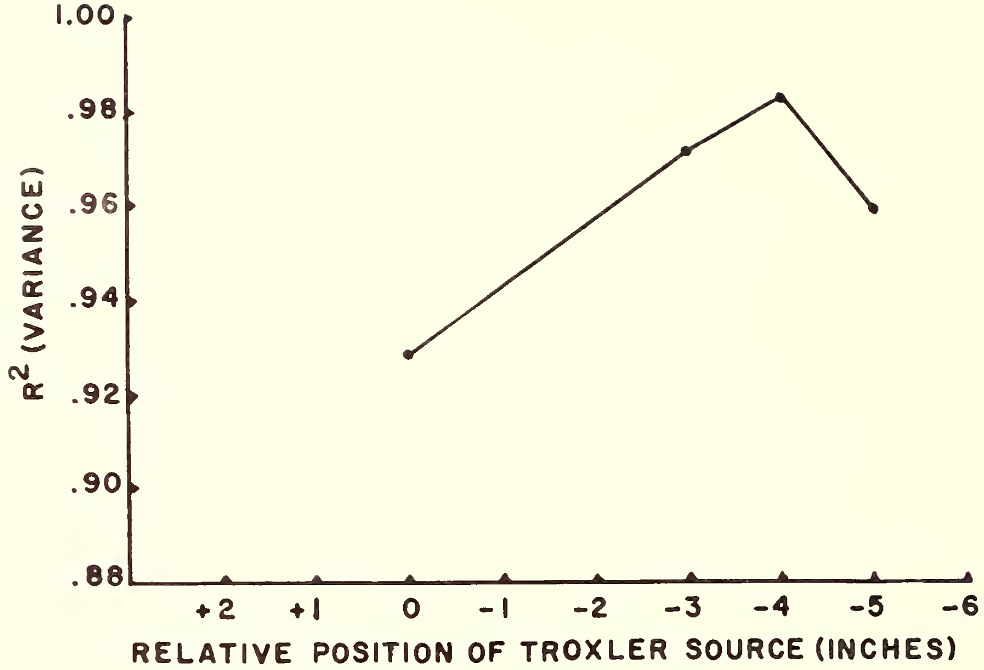

Figure 2.--Variance of soil moisture correlation data with respect to positioning of the Troxler Model 105 probe.

DISCUSSION

One purpose of this presentation is to point out reasons for field correlation of different neutron probes. Although the method employed here is probably one of the most satisfactory methods available, it is not the only, or necessarily the best, one to use in a particular instance. It must be emphasized that the correlations developed were for two different instruments used on only one study site. Extrapolation of the results to other sites or different conditions is unwarranted.

As was stated earlier, data can be correlated quite easily if two probes have identical dimensions and geometry of construction. Other situations require different handling. Manufacturers of neutron meters and probes have now developed connectors that permit the interchange of probes and scalers. Thus, two entirely different probes might be used with the same scaler, or two different scalers might be used with the same probe. It seems obvious that the correlations discussed herein need to be obtained for instruments that may be used interchangeably on the same site.

LITERATURE CITED

Lawless, G. Paul, Norman A. MacGillivray, and Paul R. Nixon.
1963. Soil moisture interface effects upon readings of neutron moisture probes. Soil Sci. Soc. Amer. Proc. 27: 502-507.

Merriam, Robert A.
1959. Nuclear probe compared with other soil moisture measurement methods. U.S. Forest Serv. Calif. Forest and Range Expt. Sta. Forest Res. Notes 146, 5 pp.

_______, and Otis L. Copeland, Jr.
1963. Brief concluding comments about neutron probe sensitivity. Soil Sci. Soc. Amer. Proc. 27: 604.

Sartz, Richard S., and Willie R. Curtis.
1961. Field calibration of a neutron-scattering soil moisture meter. U.S. Forest Serv. Lake States Forest Expt. Sta. Station Paper 91, 15 pp.

Stewart, Gordon L., and Sterling A. Taylor.
1957. Field experience with the neutron-scattering method of measuring soil moisture. Soil Sci. 83: 151-158.

Van Bavel, C. H. M.
1958. Measurement of soil moisture content by the neutron method. U.S. Dept. Agr., Agr. Res. Serv. ARS-41-24, 29 pp.

_______, D. R. Nielsen, and J. M. Davidson.
1961. Calibration and characteristics of two neutron moisture probes. Soil Sci. Soc. Amer. Proc. 25: 329-334.

_______, P. R. Nixon, and V. L. Hauser.
1963. Soil moisture measurement with the neutron method. U.S. Dept. Agr., Agr. Res. Serv. ARS-41-70, 39 pp.

DPSU/64